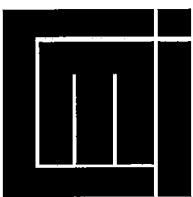


# **Economic Analysis of Land Degradation in Indonesian Upland**

Bustanul Arifin

WP 1996: 7



---

**Working Paper**  
**Chr. Michelsen Institute**  
Development Studies and Human Rights  
Bergen Norway

---

ISSN 0804-3639

# **Economic Analysis of Land Degradation in Indonesian Upland**

Bustanul Arifin

WP 1996: 7

Bergen, September 1996

Working Paper WP 1996: 7

## **Economic Analysis of Land Degradation in Indonesian Upland**

Bustanul Arifin

Bergen, September 1996.

### **Summary:**

The objective of this research is to determine factors affecting land degradation in the upland in Indonesia, and to suggest appropriate policies regarding land-use. The regression results indicate that about half of the variance in land degradation in the regional data set is explained by the variation in cropping intensity, population pressure, income per capita, transmigration, and conditioning variables. Sensitivity analysis shows that the variables for population pressure and income per capita in both data sets, and transmigration in the provincial data set are robust in explaining variation in land degradation. The results of this study could be taken as a signal to reevaluate the rice self-sufficiency policy. Efforts to increase the productivity of rice should not always be interpreted as an expansion of rice area, especially for some marginal land outside Java. Several policy recommendations are suggested by the analysis: (a) reduce intensive land-use practices, (b) reduce population pressure, and (c) promote a strategy to raise income.

### **Indexing terms:**

Land degradation  
Soil erosion  
Agriculture  
Indonesia

*To be ordered from Chr. Michelsen Institute, Fantoftvegen 38, N-5036 Fantoft, Bergen, Norway. Telephone: +47 55574000. Telefax: +47 55574166*

## **Contents**

1. Introduction	1
2. Economic theories of land degradation	2
3. Extreme bound analysis	6
4. Empirical results and discussion	8
4.1 Base regressions	8
4.2 Intensive land-use practices	10
4.3 Population pressure	11
4.4 Income per capita	11
4.5 Transmigration programme	12
4.6 Z-variables and regional characteristics	12
5. Policy implications	13
6. Conclusion and recommendations	14
References	17
Appendix	20
Tables	21

## 1. Introduction<sup>1</sup>

The role of Indonesian agriculture in the national development strategy has meant increased pressure for upland cultivation with intensive food crop practices. One part of government's economic policy has been an expansion of the agricultural area through transmigration and other extensification policies with the goal of maintaining self-sufficiency in rice and other food crops. Yet, area expansion has created pressure on marginal land and steeper slopes, thus the government has initiated several soil conservation projects throughout the country. The goals of the projects are to increase farm production and incomes, while reducing soil erosion. The projects are implemented through input and capital subsidies for terracing and related conservation measures. Persuading farmers to adopt terracing, alley cropping, agro-forestry and other conservation practices through capital and input subsidies is believed to be a panacea to minimize land degradation.

However, these agronomic policies alone cannot steer the process of land degradation unless complemented by economic and price policy. The most recent evidence regarding the sustainability of such conservation projects in Indonesia indicates that the effects of the operating subsidies are not sustainable (Huszar *et al.*, 1994). The altered management practices are neglected once the projects and the subsidies are terminated. High dependence on input subsidies is cited as the main cause of the failure of the conservation projects. The effects of the capital subsidies may persist longer for capital effect fixed in place of the land. But these effects are probably not sustainable either. If farmers lack the financial means to sustain the use of improved inputs, they may also lack the means and motivation to maintain the terraces. Evidence from other developing countries indicates that a case-by-case approach to environmental projects without the support of economy-wide changes is not successful (Schramm and Warford, 1989).

In a more specific context, the underlying cause of upland land degradation in relation to economic changes is not very well understood. Part of the problem is that the quantification of land degradation is extremely difficult. Many studies lack any historical perspectives and are often trapped in "single spot" analysis. For example, until the late 1980s or early 1990s, some economists have applied natural resources accounting approach to value the economic depreciation caused by land degradation (Magrath and Arens, 1989; Repetto *et al.*, 1989). Despite their

<sup>1</sup>This is a short version of my Ph.D. dissertation at the University of Wisconsin-Madison, USA. Sincerest appreciations, are due to the committee members: Professors Richard Barrows, Ian Coxhead, William Thiesenhusen, Russell Middleton and Calvin DeWitt for their helpful suggestions. Thanks also go to Arild Angelsen, Ussif Rashid Sumaila and participants of a seminar at the Chr. Michelsen Institute for their comments and interesting discussions. Arild Angelsen also gave detailed comments to a draft version of the paper. The responsibility for any remaining errors and omissions is, of course, mine.

contribution to the growing literature of sustainable economic development, such studies have several limitations. The study by Magrath and Arens (1989) extrapolate a specific region's estimate into the entire nation, which is clearly not very useful, and may even be directly misleading. Moreover, the economic explanation of the process of land degradation and the cause — effect relationship are not clearly specified. Consequently, such studies do not offer insight into land degradation incentives and how to reduce the erosion rate to approach the rate posed by natural process. Therefore, it is important to document and examine the nature of land degradation, both as a cause and consequence of economic change. The case of upland agriculture in Indonesia provides an exemplary opportunity to study the economic causes and consequences of land degradation under conditions typical of many developing countries. In this research, empirical estimates of the determinants of land degradation using data for all of Indonesia over time will show that intensive land use practices, population pressure, income per capita and transmigration programmes are important determinants.

The objective of this research is to determine factors affecting land degradation in the upland and to suggest appropriate policies regarding upland land-use in Indonesia or elsewhere in developing world. The study will contribute to the improvement in the analytical frameworks of land degradation literature. It will emphasize provincial and regional analyses given physical and economic disparities between Java (and Bali) and the other islands. Soil erosion estimates in this study will be derived for each province based on the information on physical resources and land use from recent and highly detailed, satellite imagery data (RePPProT, 1990). The conclusion of this study will address economic policy reforms and land degradation issues in developing countries. In the next section, we review economic theory on the causes of land degradation. In section III, we present the extreme bound analysis (EBA) as an analytical framework to identify factors affecting land degradation. In sections IV, we present and discuss the empirical results of data analysis, the implications for economic policy on land degradation issues in Indonesia and other developing countries. Finally, we conclude the paper with recommendations for future research on land degradation.

## **2. Economic Theories of Land Degradation**

The beginning of an economic theory of land degradation can be traced to the "classical" debate over the Malthusian model of population, resources and economic growth. The current form of the debate is captured in the work of followers of Malthus and Boserup — known as Neo-Malthusian and Neo-Boserupian models, respectively. This debate has contributed to the literature of agricultural development and natural resources management. In the classical Malthusian model, land is viewed as a fixed input and land degradation is a result of population pressure. The limiting force of population growth is food supply and the survival wage. Land degradation can occur under high levels of population

pressure. The concern of the Neo-Malthusian model is the race between population growth and agricultural technological change. The most important feature of the Neo-Malthusian model is that the technology is held exogenous, unrelated to population growth.

The Boserupian model argues that technological change is endogenous, preconditioned by population pressure, though it alone does not insure that new techniques will be invented or adopted. The Neo-Boserupian model focuses on the effects of population growth. Population pressure can induce technological innovation, causing the society to search for new technology or adapt the existing technology to the new environment.

According to the Neo-Malthusian models, land degradation and other kinds of environmental deterioration occur as population pressure lead to an expansion of the cropping area, forcing the cultivator to move from the best lands available to more environmentally-fragile marginal land. As population increases, new land will be opened to cultivation. The most fertile land is cultivated and settled first, but the effect of this expansion is to allow for higher rates of population growth, such as has been the case of Java. Given a fixed amount of land and a fixed agricultural technology, the cultivable area per person will decline as population increases. In order to support the subsistence level of income, families are forced to expand the area cultivated by moving to marginal land, such as sloping upland. As population pressures continue to increase, the cultivation of ever-more marginal land leads to increased land degradation. The scenario becomes more complex when farmers adopt new agricultural technology, including a decision to cultivate the land more intensively and more frequently, which has some parallels to the Boserupian theory.

Neo-Boserupian models argue that the adoption of intensive land-use practices can result in the "mining" of soil. In fragile areas, agricultural production may destroy soil structures and thin the topsoils so that the capacity to reduce erosion and moisture is decreased. Land use-practices on marginal land may involve changing vegetation with deeper rooting systems to a food crop with a more shallow rooting, which is more susceptible to erosion. More importantly, the availability of essential nutrients for plant growth declines as the soil is degraded. The natural process of soil formation is far too slow in relation to the rate of "mining", especially given the rapid growth of population. In Africa and probably in most of the outer islands of Indonesia, soil "mining" is occurring on a large scale, causing much more irreversible damage than would be the case with soils in temperate climates which tend to have a "better" structure. In this case, the role of government policy in encouraging the intensive practices, but not the soil conservation, is important in explaining land degradation in the upland. The existing scenario is actually about the same as that postulated by Neo-Malthusian model, which argues that population pressure forces the cultivation into more marginal area which again leads to land degradation.

The present study uses the extent of soil erosion as a proxy for land degradation in the upland. Factors contributing to soil erosion have been well-identified by soil scientists and agronomists as: (1) the erosivity of eroding agent, (2) the erodibility of the soil, (3) the slope of the land, and (4) the nature and management of plant cover (Mitchell and Bubenzer, 1980; El-Swaify, 1982; Morgan, 1986). The multiplicative relationship among these components is known as the Universal Soil Loss Equation (USLE), the widely-accepted method to estimate the rate of soil erosion (Wischmeier and Smith, 1978). For more detailed discussion about the modification of USLE for tropical countries, including Indonesia, see Arifin (1995).

Economic studies of land degradation, including the present study, focus on factors determining land use and management, assuming the first three factors are relatively constant. In addition to the classical works of Neo-Malthusians and Neo-Boserupians, those of Levi (1976) in Sierra Leone, Redclift (1989) in Latin America, Potter (1987) and Barbier (1989) in Indonesia, Lele and Stone (1991) in Central Africa and Southgate *et al.* (1990) in Ecuador are examples of studies concerned with land degradation. From these studies, the factors contributing to land degradation can be summarized as: (1) intensive land use practices, (2) population pressure, (3) income per capita, and (4) poverty, insecure property rights and lack of land ownership. The influence of each factor is elaborated below.

*First*, intensive land use practices refer to change in cropping practices from slash and burn to long and short fallow system and eventually to more permanent cropping (*autonomous process*) and to the increased role of the state in enhancing productivity through encouragement of intensification practices (*policy-led process*). In upland agriculture, adverse environmental effects of autonomous intensive land use would arise when the positive effects of population pressure are superseded by the detrimental effects of continuous cropping. This is especially serious for fragile soils which are very dependent on vegetative cover for moisture and stability. Such soils are commonly found in most African countries and in the outer islands of Indonesia. Cropping practices on the soils which are converted from tropical rain forest will suffer from high acidity because plant residue requires a significant amount of liming. If the trees are completely removed from the area, the crops will experience lack of water and nutrients because the water holding capacity of such soils are low.

*Second*, one possible objection to the role population pressure in the theory is that most models employ a static notion of the concept of population density. Most Neo-Boserupian authors, including Boserup herself, tend to equate the *density* of population with the *pressure* of population. This might be true in the case of *land-surplus economy*, such as early century African countries and the outer islands of Indonesia or even Java where there is a reasonable degree of freedom of population movement. An alternative explanation to reflect the concept of



population pressure is applied by Levi (1976). Assuming the pressure on resources is due only to the food demand of the population, rather than the demand generated by commercial production, such pressure can be referred as population pressure. In other words, the shift in food demand is explained by the size of population, holding preferences and income constant. Therefore, population pressure will vary with the ratio of total population to total labour force (the dependency ratio plus one).<sup>2</sup> The greater the dependency ratio, the harder a given stock of labour will work to support the dependents and the less leisure it will have. Even if the land becomes more scarce or in a *land-scarce economy*, the ratio of population to labour force in a particular region reflects the population pressure on land resources. This concept of the dependency ratio could relax the assumption of homogenous land quality imposed by the concept of population density, but would have problems since the labour stock is directly related to its flow.

*Third*, income per capita is often cited in explanations of land degradation, particularly the influence of income level on land use activity and land degradation. The theory suggests that the lower the income per capita, the higher the possibility that the upland agricultural land will be degraded (WCED, 1987). Some evidence suggests the relationship of income per capita and land degradation to follow an inverse U-shaped curve (Antle and Heidebrink, 1995). Sometimes the term poverty is used interchangeably with the income per capita concept, but these are two different concepts which should be discussed separately. A region with high income per capita might have a high percentage of poverty, and vice versa. Examples include some provinces in Kalimantan and Java, where income per capita is high but the percentage of people living below poverty line is also high. Income per capita deals with the average returns to economic activity, while the poverty is also related to the distributional pattern of the income.

*Fourth*, in Indonesia, and perhaps most other parts of the developing world, land degradation nearly originates with and most directly affects the poorest members of society (Potter, 1987). Poor farmers who are dependent on small-holdings and low-return crops may be aware of soil erosion but may not be able to afford conservation measures. The opportunity cost of conservation investment may be extremely high. In this case, poverty may prevent households from making necessary investments, including tree crop growing activities. For many households

<sup>2</sup>In demography, dependency ratio is the ratio of dependents to the labor force or the population under age 14 and over 65 to the population of 15-64 years of age.

$$\text{Dependency Ratio (DR)} = \frac{P_{<14} + P_{>65}}{P_{15-64}}$$

$$\text{Thus, population to labor ratio} = \frac{P_{<14} + P_{>65}}{P_{15-64}} + \frac{P_{15-64}}{P_{15-64}} = \text{DR} + 1$$

alternatives to agricultural production hardly exist. Richer farmers with profitable crops that are highly erosive may not consider soil conservation if their returns do not seem to be affected by soil erosion losses, which might well be the case in the short-run (Barbier, 1990). Even though there is no clear direction of causality, it is clear that many environmental problems are positively correlated with poverty. Higher rates of land degradation might increase the poverty level as farming expands onto marginal lands and poorly suited and fragile environments.

Some argue further that the movement of agricultural labour onto marginal land is related to highly inequitable farm-size holding and land tenure patterns. For Indonesia, an additional cause could be the transmigration programme, a government policy that encourages permanent cropping practices and increases population pressure on the outer islands, often in marginal areas.

The hypothesis to be tested in this study is the following: *The variation of upland land degradation in Indonesia can be explained by the degree of intensive land use practices, population pressure, income per capita, and transmigration programme.* Formal econometric and statistical techniques based on the data available will be used to test this hypothesis.

### **3. Extreme Bound Analysis**

Regression analysis is normally used to test such a hypothesis as the above one. However, a simple regression analysis is not adequate to analyze further the performance of each explanatory variable (see Levine and Renelt, 1992). An analytical framework known as extreme bound analysis (EBA) is employed in this paper to identify the magnitude of the factors affecting land degradation. The EBA is actually an empirical technique of analysis and a variant of specification searches, initially developed by Edward Leamer. In his subsequent works, Leamer (1983, 1985, 1990) suggests that data analysis should combine estimation with sensitivity analysis, which uses one alternative assumption at the time. Sensitivity analysis could demonstrate either that all alternative assumptions lead to essentially the same inferences, or that minor changes in the assumptions make major changes in the inferences. For example, a "doubtful" variable can simply be included in the equation or two different equations can be estimated, one with and one without the "doubtful" variable. Under the EBA one could determine inferences that are clearly supported by the data and are sturdy enough to withstand minor changes in the assumptions (Leamer, 1990).

The EBA techniques can be criticized because these techniques do not deal with serial correlations or non-normality (McAleer *et al.*, 1985). However, the authors' proposed method of combining backward and forward step-wise regression to handle the problems of choice of variables also suffers from the issues of inconsistency, particularly in the order of the steps and in the significant levels

(see the discussion in Leamer, 1985; Leamer and Leonard, 1985). Empirical applications of the EBA technique can be found in Cooley and LeRoy (1981), Levine and Renelt (1992), and others. Based on these empirical works, the present study uses extreme bound analysis (EBA) as part of the methodological framework. Consider the following regression:

$$Y_t = \alpha + \sum_{i=1}^n \beta_i X_{it} + \sum_{i=1}^k \gamma_i Z_{it} + u_t \quad (1)$$

where  $Y_t$  is the dependent variable,  $X_{it}$  is a vector of focus variables with coefficient  $\beta_i$ ,  $Z_{it}$  is a vector of doubtful variables with coefficient  $\gamma_i$ ,  $\alpha$  is the intercept and  $u_t$  is the disturbance term.

Suppose that the primary interest is in estimating  $\beta_i$  - the coefficient of focus variable  $X_i$ . In this case, specification uncertainty is reflected by the inclusion of  $k$  doubtful variables  $Z_i$ . This is legitimate if there is no prior information or theoretical justification to include or to exclude those as conditioning variables. For  $k$  uncertain variables, there are  $2^k$  regressions which could be defined by inclusion/exclusion some or all of the doubtful variables (Cooley and LeRoy, 1981). The regression equation for the present study can be written as follows:

$$E = \alpha + \sum_{i=1}^4 \beta_i X_i + \sum_{i=1}^4 \gamma_i Z_i + u \quad (2)$$

where  $E$  is the average annual rate of land degradation in the upland,  $X_i$  is a set of focus variables and  $Z_i$  is a subset of variables chosen from a pool of variables which are based on available theory as a potentially important explanatory variables of land degradation. The dependent variable  $E$  is calculated using a modified USLE, and available both for six regions (Sumatra, Java-Bali, Kalimantan, Sulawesi, Maluku-Nusa Tenggara and Irian Jaya), and for all 27 provinces in Indonesia. A much more detailed information about the average annual rate of land degradation can be found in Arifin (1995).

The focus variables are: intensive land use practices, represented by proxy cropping intensity (CI-POTEN), population pressure (PRESSURE), non-oil income per capita (GDP/CAP), and cumulative transmigration up to 1990 (TRANS-90). The pool of variables  $Z_i$ , which could affect the rate of land degradation include the 1961 population density (DENS-61), annual population density in the current year (POP-DENS), government expenditure on transmigration (TRANSEX), percentage of population living below poverty line in 1987 (POVER-87), and a set of dummy variables. In the regional data set, two dummies will used: Java-Bali (D\_JAVA+) and non-Java (D\_NOJAVA). In the provincial data set, seven dummies will be used: Sumatra (D\_SUMTRA), Java and Bali (D\_JAVA+), Maluku-Nusa Tenggara (D\_MLK-NT), Kalimantan (D\_KALMTN), Sulawesi (D\_SULWSI), and all regions of outside Java combined as non-Java dummy

(D\_NOJAVA). For the definition and data sources of these variables, see Table 6.

The extreme bound analysis (EBA) will involve varying the subset of Z variables included in the regression. The ultimate objective is to find the widest range of coefficient estimates on each of the focus variables, or variable of interest, that are not rejected in a standard hypothesis test. In this study, the choice of combining sets of Z variables is limited to only three. First, the priority is given to the first three of the four continuous quantitative variables; second priority is the set of qualitative (regional dummy) variables. Including too many "doubtful" variables in the regression would eventually cause the variable of interest to lose its significance. Therefore, the total number of explanatory variables included in each regression is between four and seven.

Levine and Renelt (1992) have noticed that the EBA may cause multicollinearity, inflate the coefficient standard errors, and exaggerate the range on the coefficient of interest. However, since the multicollinearity really reflects a weak-data problem (Leamer, 1990; Kennedy, 1992), one should not simply think that the regression is bad and decide to drop a particular variable that might be important. Levine and Renelt (1992) further suggest that multicollinearity is not a procedural problem but rather represents the inability to identify a statistical relationship that is insensitive to the conditioning set of variables (page 944).

## 4 Empirical Results and Discussion

### 4.1 Base regressions

As explained previously, two data sets are used in the study: regional and provincial. The regional data set is an aggregate of six different regions or big islands of Indonesia: Sumatra, Java-Bali, Kalimantan, Sulawesi, Maluku-Nusa Tenggara, and Irian Jaya. Provincial data set is a detailed provincial characteristics of all provinces (except the special territory of Capital Jakarta and the youngest province East Timor). Regression results of the "base" variables in the regional and provincial data sets are respectively presented in equation (3) and (4) as follows (t-statistics in parentheses):

$$\begin{aligned} \text{E-UPL} = & 55.9 + 0.342 \text{ CI-POTEN} + 10.77 \text{ PRESSURE} \\ & (2.42) \quad (2.78) \quad (2.23) \\ & - 0.110 \text{ GDP/CAP} + 0.0002 \text{ TRANS90} \\ & (-4.56) \quad (0.03) \\ R^2 = & 0.45, \text{ SEE} = 23.13, F = 12.26 \end{aligned} \quad (3)$$

$$\begin{aligned} \text{E-UPL} = & -45.3 + 0.259 \text{ CI-POTEN} + 30.68 \text{ PRESSURE} \\ & (-2.11) \quad (3.37) \quad (6.81) \\ & - 0.083 \text{ GDP/CAP} + 0.118 \text{ TRANS90} \\ & (-3.68) \quad (3.14) \\ R^2 = & 0.21, \text{ SSE} = 57.20, F = 16.20 \end{aligned} \quad (4)$$

The variables have the signs predicted by a wide class of models. All variables but TRANS90 in equation (3) are significant at the 0.05 significance level. In the regional data set, the base variables explain about half of the variance in upland land degradation in the pooled cross section-time series data from the 1980-1991 period. In the provincial data set (equation 4), the base variables explain about 21 percent of the variance in land degradation in the upland. Standard errors of regression in both data sets are small so that the F-ratio of the regressions is significant at the 0.01 level. This implies that the model performs well in explaining variation in land degradation in the upland (E-UPL) using all independent variables in the base regression. Durbin-Watson tests show no autocorrelation among the residuals in both data sets, implying no problems from using pooled data of time series and cross sections to estimate the land degradation models.

The addition of conditioning sets of "doubtful" Z-variables to the base models results in a wide range of changes in regression coefficients ( $\beta$ ), coefficients of determination ( $R^2$ ), and F and t statistics. The sources of these changes can be the relative sensitivity of the focus variables, and the relationship between the focus and conditioning variables. Tables 1 and 2 present correlations among variables for the regional and provincial data sets, respectively. From the tables, it is clear that some variables may be a source of multicollinearity. However, because the present study is interested in the nature of and the effects of doubtful variables on base variables, no statistical transformation has been performed to estimate or adjust for the multicollinearity. Also, explanation will be advanced by using more economic theory in the form of additional restrictions since multicollinearity is not a source of bias in regression coefficient estimation (see Kennedy, 1992). A quite high correlation coefficient ( $r$  is either negative or positive 0.9 or more at 95 percent significant level) is found among the variables of cropping intensity (CI-POTEN), population density (POP-DENS), initial population density: (DENS-61), dummy variables of outside Java (D\_NOJAVA) and of Java and Bali (D\_JAVA+). This observation supports the Boserup hypothesis that society responds to population density, the higher the population density, the higher the cropping intensity.

Tables 3 and 4 present the extreme bound analysis (EBA) for each of focus variables in the regional and provincial data sets, respectively. In both data sets, the sensitivity analysis shows that variables of population pressure and income per capita are robust and significantly different from zero. The robust and positive relationship between population pressure and land degradation is consistent with a wide assortment of economic theories of land degradation. Also, income per capita is inversely related to land degradation, shown by a robust negative coefficient of GDP/CAP variable.

A robust and positive regression coefficient is also found in the relationship between upland land degradation and the transmigration up to 1990 (TRANS90)

in the provincial data set. However, in the regional data set the coefficient is not statistically significant, perhaps because the amount of transmigration varies within region. Both extreme lower and upper bounds and the base regression yield a regression coefficient not different from zero. In addition, the regression coefficient for cropping intensity is positive but fragile in both data sets. By adding some combinations of the doubtful Z-variables, the extreme lower bound of the regression coefficient differ significantly from the base regression. A more detailed discussion of the robustness/fragility of each focus variable is given below.

#### 4.2 *Intensive Land-Use Practices*

For the base regression, the effects of the intensive land-use practices variable on land degradation in the upland is consistent in both regional and provincial data sets. Recall that the proxy for intensive land-use practices is the ratio of harvested area of upland food crops to the potential arable upland, or simply termed the cropping intensity of potential upland. The working hypothesis is that the higher the cropping intensity in previous years, *ceteris paribus*, the higher the chance for the upland to experience degradation. Java has had the highest cropping intensity for many years. Harvested area of all food crops in Java is higher than that in other regions, where Javanese farmers can harvest their crops up to three times a year.

Although Java has experienced higher cropping intensity, it is important to note that the dependent variable is an *estimate* of land degradation based on USLE, rather than *actual* degradation. The *actual* degradation can only be measured in the field. One difficulty is that conservation practices are more extensive in Java than in the other regions (see Barbier, 1989), and conservation practices are not included in the modified USLE. However, much degradation in Java occurred prior to the implementation of government programmes and subsidies for conservation measures, which started in the 1970s or early 1980s. Research indicates that in many watersheds in Java the subsidy approach has *not* led to sustainable conservation practices in the long run (Huszar *et al.* 1994).

The extreme bound analysis (EBA) shows that the relationship between the cropping intensity variable and land degradation is fragile. Including some conditioning sets of doubtful or Z-variable changes the significance level of the cropping intensity variable. The fragility of the cropping intensity variable (CI-POTEN) in explaining the variance of land degradation can be traced to the relationship between cropping intensity and the set of Z-variables. Cropping intensity is extremely high in Java-Bali, but so is also land degradation. Since the combining sets of Z-variables have a pattern of variation similar to that of the cropping intensity variable, inclusion of the combining set decreases the significance level of cropping intensity variable. In other words, the fragility is

mostly caused by the presence of variables that are in nature highly correlated with the CI-POTEN such as TRANSEX and DENS-61 and POP-DENS.

### *4.3 Population Pressure*

For the base regression, the variable for population pressure (dependency ratio plus one) is significant at 0.05 level in determining the rate of land degradation in the upland in both regional and provincial data sets. In other words, the null hypothesis that there is no relationship between population pressure and upland degradation can be rejected. In addition, the EBA shows a robust positive relationship in the regression coefficient for population pressure variable (at 0.05 level for the base and the higher bound and 0.1 level for the lower bound), after inclusion of combining sets of Z-variables.

As in the case of cropping intensity, population pressure is also higher in Java, with a high initial population density. The robustness of population pressure variable can be seen from the Tables 3 and 4. After inclusion of "doubtful" variables, even with those having high correlation with the focus variables (such as DENS-61, TRANSEX and some dummy variables), the changes in the coefficient are still within the limit of  $\beta_i$  + two standard deviations. One concern with this population pressure variable is the difference in the regression coefficient between regional and provincial data set. For the base and upper bound extreme, the coefficient in provincial data is about twice as high as that in regional data set; but for the lower bound, the coefficients in the two data sets are about the same. This difference could have a significant impact on the elasticity of the variable, hence its policy implications, which could be caused by the nature of the variation in the dependent variable, rather than the nature of the population pressure variable.

### *4.4 Income Per Capita*

The non-oil income per capita variable shows a negative sign in both data sets, as hypothesized. The lower the income, the higher the upland land degradation. For most farm households, lower income means lower opportunity to earn extra cash within the non-oil sectors. This translates into a higher dependency on agriculture. The EBA also shows a robust and negative relationship between the variable GDP/CAP and land degradation in both data sets, all at the 0.05 significance level. Inclusion of conditioning sets of Z-variables does not alter the sign of the regression coefficient. The result is consistent with contemporary theories, suggesting that poverty is an important contributor to land degradation (WCED, 1987).

Interestingly, the income per capita variable (GDP/CAP) does not show a strong negative correlation with the poverty variable (POVER-87), cf. Table 2. One

explanation is that any per capita or average income variable cannot incorporate the distribution of income among individuals. Even though it is clear that income distribution may explain some upland land degradation, a detailed discussion is beyond the scope of this study. The poverty level in 1987 does not represent poverty throughout the 1980-1991 observation period, which was one reason for excluding POVER-87 as one of the focus variables. Moreover, econometric analysis cannot explain the underlying process by which landlessness and small farm-size cause the land degradation.

#### *4.5 Transmigration Programme*

Cumulative transmigration up to 1990 has a statistically significant impact on land degradation in the provincial data set (at 0.05 level), but not in the regional data set. Aggregating the information of transmigration by region obscures important variations between provinces within the region. Some provinces in Sumatra (Lampung, South Sumatra, and Riau), Kalimantan (West and Central Kalimantan) and Sulawesi (Central and Southeast Sulawesi) have been chosen by the government as priority areas for transmigration.

This may explain why the EBA for the transmigration variable shows a fragile, positive, but not statistically significant relationship for the regional data set. Both in the base regression and in the regression with the Z-variables included, the coefficient for the transmigration variable is not significantly different from zero, sometimes even negative using the regional data. Transmigration increases both cropping intensity and population pressure, both of which could contribute to land degradation.

#### *4.6 Z-Variables and Regional Characteristics*

Inclusion of the "doubtful" Z-variables in the regression analysis produces some interesting results. The Z-variables might influence land degradation in the upland, but the data structure, weak theoretical justification, and potential multicollinearity problems prevent these variables from being chosen as focus variables. For example, the initial population density (DENS-61) has a high correlation with the present population density (POP-DENS) and the focus variable of cropping intensity (CI-POTEN). Also, the proxy variable of government expenditure on transmigration (TRANSEX) has a high correlation with transmigration variable (TRANS-90) and with initial population density (DENS-61). Regional characteristics which can only be classified as dummy variables have helped to fine-tune the regression analysis. Almost all dummy variables in the models are statistically significant in both data sets, and a rather constant pattern is observed. In the regional data set, only dummy for non-Java (D\_NOJAVA) and for Java-Bali (D\_JAVA) are used in order to avoid perfect collinearity. Dummy variables for



Sumatra and for Kalimantan consistently have negative signs, while other dummies have positive signs in the equations.

The main interpretation of these results is that the pattern of land degradation in Indonesia exhibits great regional variations. The regional dummy variables capture the effects of variables that are not included in the analysis, but that have important region-specific impacts on land degradation. For example, the soil erodibility factor (K) in the USLE model does not fully incorporate information on the depth of top soil – an important characteristic that varies geographically across the nation. Economic data on land use differences among regions cannot be captured in the regression models. Extensive shifting cultivation practices in Kalimantan may explain the low rate of upland degradation. However, because the land-use data of Central Bureau of Statistics (CBS) do not distinguish between permanent cropping and shifting cultivation, this important regional difference is omitted from the focus variables but it is captured by the regional dummy variables.

## 5. Policy Implications

The regression results can be used to analyze the likely land degradation response to policy-driven change in the independent variables. The concept of elasticity, the change in land degradation per one percent change in the independent variables, is a unit-free measure, where values are computed at the means of each independent variable (Table 5). It should be noted, however, that elasticities are not constant but change when measured at different points along the regression surface. As seen from Table 5, the elasticities of regression of the focus variables are less than one and about the same in both regional and provincial data sets, except for the population pressure variable in the provincial data sets which is 1.74. Interpretation for policy formulations will rely on the corresponding data set. Although the effects of the focus variables on land degradation are generally small, since elasticity is built on a *ceteris paribus* assumption for values of all other variables, an effect of a simultaneous change in several of these variables would be more profound.

For the cropping intensity variable, the elasticity is 0.11 in both data sets. Computed at means, a one-percent increase in the ratio of harvested area to potential arable land would increase land degradation 0.11 percent, holding other variables constant. Given only a slight fragility in the EBA results for this variable, policies that encourage more intensive practices on upland should be reassessed. Application of modern technologies in crop production in the upland should not always be complemented with more "soil mining" activities. As already explained, the Indonesian government encourages more intensive practices throughout the nation as part of a set of policies to increase food production, particularly outside Java and Bali. The transmigration policy is a significant

example of such efforts. At national level, the policy is aimed at achieving and maintaining self-sufficiency in rice production. Yet, increasing the harvested area of lowland or irrigated rice field can have a much greater impact on rice production than promoting permanent cultivation practices on the uplands. For example, government might concentrate the development program and application of appropriate bio-chemical technology on existing lowland rice field. Expanding lowland rice area through irrigation development is another attractive option.

The point is that promoting practices in the upland may have a smaller effect on production than a focus on lowland or irrigated rice production. Moreover, if intensive land-use practices occur on steep upland slopes and no conservation efforts are adopted, the rate of land degradation will increase. Increasing harvested area in a region with more land prone to degradation would not be appropriate if the strategy is to achieve sustainable development.

The elasticities for population pressure variable is 0.70 for the regional data set and 1.74 for the provincial data set. Using the regional data, in order to reduce land degradation by one percent, a population policy must produce a 1.4 percent decrease in population pressure. However, using the provincial data where population pressure variable is more elastic, to reduce land degradation by one percent, a decrease of only 0.6 percent in population pressure would suffice.

The elasticities of income per capita variable are -0.69 and -0.44 respectively in regional and provincial models. A policy to reduce land degradation can be complemented with poverty alleviation programmes that increase regional income. The fact that a rural economic development strategy can also help reduce land degradation should encourage the Indonesian government to vigorously pursue policies to increase rural incomes and to reduce rural poverty.

Finally, elasticities for transmigration variable in the regional and provincial data sets are 0.001 and 0.18, respectively. The small and statistically non-significant effect of transmigration variable in the regional data set have been explained in the previous section. In the provincial data set, for every one percent increase in the number of transmigrants, the rate of land degradation is threatened to increase by 0.18 percent, holding other variables constant.

## **6. Conclusion and Recommendations**

This paper has presented empirical estimates of the regression and extreme bound analysis (EBA) of the factors affecting land degradation in the upland. The study concludes that about half of the variation in land degradation in the provincial data set can be explained by variation in the extent of intensive land use practices, population pressure, income per capita and the transmigration program. In the

regional data set, only 21 percent of the variation in the dependent variable of land degradation can be explained by these variables.

Sensitivity analysis using the extreme bound analysis (EBA) techniques shows that the variables of population pressure and income per capita in both the provincial and regional data sets, and transmigration in the provincial data set are robust in explaining the variation in land degradation. Based on the EBA, the most confident policy recommendation to deal with land degradation would be for economic policies that reduce population pressure and increase in per capita income.

Elasticity analysis of the regression results suggest that, on average, a one-percent decrease in population pressure would cause a decrease in land degradation of 1.74 percent based on provincial data, and 0.7 percent based on the regional data. Also, one percent increase in income per capita could mean a decline in land degradation of 0.44 percent based on provincial data, or 0.69 percent based on the regional data. Not much can be concluded from the present study about the transmigration policy. The results indicate, however, that transmigration is not an answer to population pressure and land degradation. Other research has shown that spontaneous or inter-rural migration occurs to sites around transmigration area, probably due to population pressure in the areas of origin.

Several policy recommendations are suggested by the analysis: (1) reduce the degree of intensive land-use practices in the uplands; (2) reduce population pressure, and (3) promote a strategy to raise income.

*First*, despite its fragility in the EBA regressions and the inherent data problems, the positive relationship between intensive land-use practices and land degradation remains important. A high degree of cropping intensity can generate soil-mining activities which are particularly harmful in the regions with shallow top soils such as Sulawesi and Nusa Tenggara. For these regions, reducing the expansion rate of harvested area is one way to lower the rate of the rate of land degradation. In addition, the intensive land use practices may have a substantial long-run impact as well. According to the correlation matrix, the intensive practices are highly correlates with population density. Although causality is not clear, it is likely that not only is high cropping intensity a response to increased population pressure, but also allows for higher levels of population to develop through less out-migration, more in-migration and perhaps even through a higher birth rate. Thus, more intensive land use practices may be an initial condition for higher population pressure which leads to a higher degree of land degradation through even higher levels of cropping intensity.

*Second*, the results strongly suggest policies to reduce population pressure as an important part of a strategy to reduce land degradation. The policies for reducing population pressure include not only a population control policy, but also

diversification in rural development. Employment creation in rural areas, particularly in the non-farm sector is a likely source of increasing regional income. The development of the non-farm rural sector should become a priority agenda on Indonesian policy. A dual policy strategy — population control and non-farm rural development — could reduce the pressure on agricultural land resources, which turn could reduce land degradation. The choice between these two policies depends on the specific implementation possibilities, the costs and impacts of the specific options, and the urgency for action in the region or province.

*Third*, a major concern must be to prevent a worsening trend of declining income per capita, as land degradation reduces the farmers' income from food crops. Expansion of non-farm activities is an example of policy option that can increase income per capita. Subsequential policies can then be directed towards the activities that can reduce the rate of land degradation and increase the returns to land at the same time. These include measures to reduce the population pressure, application of fertilizer and other modern inputs, and price policies that can boost income per capita.

The results of this study could be taken as a signal to reevaluate the rice self-sufficiency policy. Efforts to increase the productivity of rice should not always be interpreted as an expansion of rice area, especially for some marginal land outside Java. Adoption of more modern technologies such as high-yielding varieties and bio-chemical inputs could be a more appropriate, if not the only, choice for increasing agricultural productivity in general. In addition, more attention should be given to food crop diversification, particularly to reduce the high dependency on rice consumption. This might reduce the pressure to maintain rice self-sufficiency on the production side, which can be associated with the land degradation phenomenon.

The present study can also be used as an input in setting the agenda for future research on the causes of land degradation in Indonesia and other countries. One critical research need is to develop an internationally consistent system for classification of land use and bio-physical land systems. Estimation of the rates of land degradation through time would be much improved by such a system. A second major research need is an improved method to calculate soil loss using a modified version of the universal soil loss equation. These improved methods could include not only more accurate and detailed parameter estimates but also more reliable and well-tested methods for interpolation and approximation of parameters not extensively studied in a local context. Finally, village level studies are still needed to confirm the findings generated in this study. The extreme bound analysis (EBA) performed in the present study could be useful for those interested in other variables relevant to land degradation, such as income per capita and transmigration. As a by-product, forward and backward industry linkages to land degrading activities can also be determined, which would aid greatly the

specification of more detailed policy recommendations than was possible in this study.

Another important area for future research is to estimate the effect on natural resource degradation of changes in the income per capita and the distribution of income. For example, Gini ratios to depict income distribution could have been included in the regression analysis. If the best resources are controlled by a few very rich families, the robust and negative correlation between income per capita and land degradation might have been even stronger. The relationship between income level, income distribution and land degradation is an important topic for further research. The data from the Indonesian Agricultural Census series could be a point of departure for the analysis, as Indonesia has consistently conducted the censuses every ten years since 1963.

## References

- Antle, J.M. and G. Heidebrink. 1995. "Environment and Development: Theory and International Evidence", *Economic Development and Cultural Change*, 43 (3): 603-626.
- Arifin, Bustanul. 1995. *The Economics of Land Degradation: The Case of Indonesian Upland*. Ph.D. Dissertation. University of Wisconsin-Madison, USA.
- Barbier, E.B. 1989. "Cash Crops, Food Crops, and Sustainability: The Case of Indonesia", *World Development*, 17 (6): 879-895.
- Boserup, E. 1989. "Agricultural Growth and Population Change", in J. Eatwell, M. Milgate, P. Newman (eds.), *Economic Development: The New Palgrave*. New York: Norton.
- Central Bureau of Statistics (CBS). (Various Issues). *Indonesia: Statistical Yearbook*. Jakarta: Central Bureau of Statistics.
- Central Bureau of Statistics (CBS). 1991. *Regional Income by Provinces in Indonesia by Industrial Origin 1983-1989*. Jakarta: Central Bureau of Statistics.
- Cooley, T.F. and S.F. LeRoy. 1981. "Identification of Money Demand", *American Economic Review*, 71 (6), December: 825-844.
- Hamer, W. I. 1982. *Final Soil Conservation Consultant Report*. Technical Note No. 26, FAO Project AGOF/INS/78/006. Bogor, Indonesia: Centre for Soil Research.
- Huszar, P.C., H.S. Pasaribu and S.P. Ginting. 1994. "The Sustainability of Indonesia's Upland Conservation Projects", *Bulletin of Indonesian Economic Studies*, 30 (1): 105-122.
- Kennedy, P. 1992. *A Guide to Econometrics: Third Edition*. Cambridge: Massachusetts.
- Leamer, E. 1983. "Let's Take the Con out of Econometrics", *American Economic Review*, 73 (1), March: 31-43.
- Leamer, E. 1985. "Sensitivity Analysis Would Help", *American Economic Review*, 75 (5), June: 308-313.

- Leamer, E. 1990. "Specification Problems in Econometrics", in J. Eatwell, M. Milgate and P. Newman (eds.), *Econometrics: The New Palgrave*. New York: W.W. Norton: 238-245.
- Leamer, E. and H. Leonard. 1983. "Reporting the Fragility of Regression Estimates", *Review of Econometrics and Statistics*, 65, May: 306-317.
- Lele, U. and S.W. Stone. 1991. *Population Pressure, the Environment, and Agricultural Intensification: Variations on the Boserup Hypothesis*. Washington, DC: The World Bank.
- Levi, J.F.S. 1976. "Population Pressure and Agricultural Change in the Land-Intensive Economy", *Journal of Development Studies*, 13 (1): 61-78.
- Levine, R. and D. Renelt. 1992. "A Sensitivity Analysis of Cross-Country Growth Regressions", *American Economic Review*, 82 (4), September: 942-963.
- Magrath, W. and P. Arens. 1989. *The Costs of Soil Erosion on Java: A Natural Resource Accounting Approach*. Washington, D.C.: The World Bank.
- McAleer, M., A.R. Pagan, and P.A. Volker. 1985. "What Will Take the Con out of Econometrics ?", *American Economic Review*, 75 (3), June: 293-307.
- Mitchell, J. Kent and Gary Bubenzer. 1980. "Soil Loss Estimation" in M.J. Kirkby, M. J. and R.P.C. Morgan (eds.), *Soil Erosion*. New York: John Wiley and Sons: 17-62.
- Morgan, R.P.C. 1986. *Soil Erosion and Conservation*. Harlow, Essex: Longman Scientific.
- Potter, L. 1987. "Degradation, Innovation, and Social Welfare in the Riam Kiwa Valley, Kalimantan, Indonesia", in P. M. Blaikie and H. Brookfield (eds.) *Land Degradation and Society*. New York: Methuen: 164-175.
- Redclift, M. 1989. "The Environmental Consequences of Latin America's Agricultural Development", *World Development*, 17 (3): 356-377.
- Regional Physical Planning Programme for Transmigration (RePPPProT). 1990. *The Land Resources of Indonesia: A National Overview*. London and Jakarta: Foreign and Commonwealth Office of the United Kingdom and Ministry of Transmigration of Government of Indonesia.
- Repetto, R., W. Magrath, M. Wells, C. Beer, and F. Rossini. 1989. *Wasting Assets: Natural Resources in the National Income Accounts*. Washington, D.C.: World Resources Institute.
- Schramm, G. and J. Warford. 1989. *Environmental Management and Economic Development*. Baltimore: The Johns Hopkins University Press.
- Southgate, D., R. Sierra, and L. Brown. 1991. "The Causes of Tropical Deforestation in Ecuador: A Statistical Analysis", *World Development*, 19 (9) September: 1145-1151.
- Thiesenhusen, W. 1991. "Implication of the Rural Land Tenure System for the Environmental Debate: Three Scenarios", *The Journal of Developing Areas*, 27: 1-24.
- Wischmeier, W. and D. D. Smith. 1978. *Predicting Rainfall Erosion Losses: A Guide to Conservation Planning*. Agriculture Handbook No. 537. Washington, D.C.: USDA

World Commission on Environment and Development (WCED). 1987. *Our Common Future*. New York: Oxford University Press.

## Appendix

### Steps and Procedures to Perform the Extreme Bound Analysis:

- (1) Run the "base" regression  
This base regression consists of four focus variables only: intensive land use practices, population pressure, income per capita and transmigration. A more in-depth analysis can be directed towards the variable of interest within those focus variables. The focus variables will always be included in each regression with other combining sets of "doubtful" Z variables.
- (2) Run the extreme bound regressions  
In this case, three or fewer combinations of available Z variables are included in the regressions. Extreme highest and lowest values of the coefficient of the variable of interest that cannot be rejected at significant level of 95 and/or 99 percent. The extreme upper or lower bound is defined by the group of Z variables that produces the maximum or minimum value of coefficient.
- (3) Determine robustness/fragility of the variable of interest  
If  $\beta_i$  remains significant and of the same sign at the extreme bounds, then this i-th variable of interest is called *robust*. In other words, if  $\beta_i$  plus or minus two standard deviations is still within the range of the upper and lower extreme bounds, one can maintain a fair amount of confidence in that partial correlation between the dependent variable and that particular explanatory variable. However, if the coefficient does not remain significant or if the coefficient changes sign, it implies that alterations in the conditioning information set change the statistical inferences. In this case, that variable of interest is said to be *fragile* in explaining the variation in the dependent variable. It should be noticed that if one is not able to find a robust result, particularly in a pooled cross-section and time series regression, this means that there is not enough independent variation in that variable to explain the variation in the dependent variable, in this case the average land degradation in the upland.



**Table 1. Regional Data: Coefficient Correlations among All Variables Used in the Study**

Variable	Variable						
	E-UPL TRANSEX	CI-POTEN POVER-87	PRESSURE D_NOJAVA	GDP/CAP	TRANS90	POP-DENS	DENS-61
CI-POTEN	0.361						
PRESSURE	0.479	0.566					
GDP/CAP	-0.373	0.317	-0.014				
TRANS90	-0.227	-0.365	-0.163	0.091			
POP-DENS	0.344	0.990	0.533	0.331	-0.351		
DENS-61	0.346	0.993	0.548	0.302	-0.373	0.997	
TRANSEX	0.171	0.541	0.357	0.235	0.373	0.566	0.556
POVER-87	-0.277	-0.353	-0.303	-0.130	-0.495	-0.351	-0.341
D_NOJAVA	-0.683						
	-0.282	-0.988	-0.548	-0.382	0.367	-0.991	-0.993
D_JAVA+	-0.544	0.293					
	0.282	0.988	0.548	0.382	-0.367	0.991	0.993
	0.544	-0.293	-1.000				

Notes:

- E-UPL = Average land degradation in the upland (ton/ha)
- CI-POTEN = Potential cropping intensity or ratio of harvested area of food crops to potential upland (%)
- PRESSURE = Population pressure or dependency ratio plus one
- GDP/CAP = Non-Oil agricultural income per capita (Thousand Rupiah)
- TRANS90 = The number of cumulative transmigration up to 1990 (people)
- POP-DENS = Annual population density (people/km<sup>2</sup>)
- DENS-61 = Initial population density of 1961 (people/km<sup>2</sup>)
- TRANSEX = Government Expenditures on Transmigration Program (Million Rupiah)
- POVER-87 = Percentage of people living under poverty line in 1987 (%)
- D\_NOJAVA = Dummy variable for non-Java (1 for region outside Java and 0 for Java)
- D\_JAVA+ = Dummy variable for Java-Bali (1 for Java and 0 for outside Java)

Table 2. Provincial Data: Coefficient Correlations of Dependent and All Independent Variables used in the study

Variable	Variable													
	E-UPL	CIPOTEN	PRESSURE	GDP/CAP	TRANS90	POPDENS	DENS61	TRANSEX	POVER87	DNOJAVA	DSUMTRA	DJAVA+	DMLKNT	DKALMTN
CI-POTEN	0.152													
PRESSURE	0.347	-0.014												
GDP/CAP	-0.166	-0.150	0.113											
TRANS90	0.019	-0.420	-0.109	0.236										
POP-DENS	0.241	0.879	0.184	-0.152	-0.505									
DENS-61	0.187	0.922	0.142	-0.152	-0.506	0.987								
RANSEX	0.432	0.470	0.337	-0.068	-0.328	0.620	0.568							
POV-87	0.064	-0.127	-0.057	0.055	-0.148	-0.135	-0.150	-0.146						
D.NOJVA	-0.218	-0.793	-0.216	0.076	0.490	-0.956	-0.940	-0.626	0.056					
D.SUMTRA	-0.182	-0.323	-0.159	0.039	0.547	-0.346	-0.363	-0.191	-0.502	0.385				
D.JAVA+	0.218	0.793	0.216	-0.076	-0.490	0.956	0.940	0.626	-0.056	-1.000	-0.385			
D.MLK-NT	0.012	-0.070	-0.214	-0.343	-0.282	-0.108	-0.104	-0.153	0.261	0.163	-0.225	-0.163		
D.KALMTN	-0.315	-0.231	-0.078	0.491	0.178	-0.300	-0.275	-0.164	0.154	0.242	-0.335	-0.242	-0.142	
D.SULWSI	0.298	-0.174	0.201	-0.203	-0.123	-0.226	-0.214	-0.164	0.344	0.242	-0.335	-0.242	-0.142	-0.211

Notes:

- = E-UPL
  - = CI-POTEN
  - = PRESSURE
  - = GDP/CAP
  - = TRANS90
  - = POP-DENS
  - = DENS-61
  - = TANSEX
  - = POVER-87
  - = D\_NOJAVA
  - = D\_SUMTRA
  - = D\_JAVA+
  - = D\_MLK-NT
  - = D\_KALMTN
  - = D\_SULWSI
- = Average land degradation in the upland (ton/ha)
- = Potential cropping intensity or ratio of harvested area of food crops to potential upland (%)
- = Population pressure or dependency ratio plus one
- = Non-Oil agricultural income per capita (Thousand Rupiah)
- = The number of cumulative transmigration up to 1990 (people)
- = Annual population density (people/km<sup>2</sup>)
- = Initial population density of 1961 (people/km<sup>2</sup>)
- = Government expenditure of transmigration (Million Rupiah)
- = Percentage of people living under poverty line in 1987 (%)
- = Dummy variable for non-Java (1 for region outside Java and 0 otherwise)
- = Dummy variable for Sumatra (1 for Sumatra 0 otherwise)
- = Dummy variable for Java-Bali (1 for Java and 0 otherwise)
- = Dummy variable for Maluku-Nusa Tenggara (1 for Maluku-Nusa Tenggara and 0 otherwise)
- = Dummy variable for Kalimantan (1 for Kalimantan and 0 otherwise)
- = Dummy variable for Sulawesi (1 for Sulawesi and 0 otherwise)

**Table 3. Regional Data: Sensitivity Analysis for Focus Variables Determining Land Degradation (Dependent Variable: Land Degradation in the Upland, 1980-1991 by Region)**

Focus variables	$\beta$	Std.error	t	R <sup>2</sup>	DW	Other variables	Note
Cropping intensity	high: 2.130**	0.576	3.69	0.53	1.80	TRANSEX, D_NOJAVA	Fragile
	base: 0.343**	0.123	2.78	0.45	1.92		
	low: 0.233	0.178	1.31	0.49	1.71	TRANSEX, POVER87	
Population pressure	high: 15.351**	4.717	3.25	0.56	1.72	dens-61, d_NOJAVA	Robust
	base: 10.773**	4.834	2.23	0.45	1.92		
	low: 9.601*	4.877	1.97	0.46	1.93	DENS-61	
Income per capita	high: -0.066**	0.027	-2.41	0.53	1.78	TRANSEX, D_JAVA+	Robust
	base: -0.110**	0.024	-4.56	0.45	1.92		
	LOW: -0.138**	0.024	-5.67	0.54	1.98	POP-DENS, DENS-61, POVER-87	
Transmigration-1990	high: 0.000	0.006	0.03	0.46	1.92	POP-DENS	Fragile
	base: 0.000	0.006	0.03	0.45	1.92		
	low: -0.006	0.006	-1.03	0.56	1.72	TRANSEX, D_JAVA?	

Notes: (1) \*\* and \* indicate significant at  $\alpha=0.05$  and  $\alpha=0.1$ , respectively

(2) The base  $\beta$  is the estimated coefficient from focus variables: cropping intensity (CI-POTEN), population pressure (PRESSURE), non-oil income per capita (GDP/CAP), and cumulative transmigration up to 1990 (TRANS-90). The high  $\beta$  is the estimated coefficient from the regression with the extreme high bound, and the low  $\beta$  is the estimated coefficient from the regression with the extreme lower bound.

(3) Other variables are the Z-variables included in the base regression to produce the extreme bounds.

(4) The variable is *robust* when the estimated coefficient falls within the range of  $\beta$ , + two times its standard error and *fragile* when otherwise (see Levine and Renelt, 1992).

**Table 4. Provincial Data: Sensitivity Analysis for Focus Variables Determining Land Degradation (Dependent Variable: Land Degradation in the Upland, 1980-1991 by Province)**

Focus variables	$\beta$	Std.error	t	R <sup>2</sup>	DW	Other variables	Note
Cropping intensity	high: 0.472**	0.225	2.11	0.23	2.18	DENS-61, D_NOJAVA	Fragile
	base: 0.259**	0.077	3.37	0.21	2.14		
	low: 0.014	0.104	0.13	0.43	2.09	TRANSEX, D_JAVA+, D_SULWSI	
Population pressure	high: 32.966**	4.638	3.78	0.22	2.06	D_MLK-NT	Robust
	base: 30.683**	4.505	6.81	0.21	2.14		
	low: 9.378**	4.558	2.06	0.43	2.09	TRANSEX, D_JAVA+, D_SULWSI	
Income per capita	high: -0.050**	0.020	-2.51	0.42	1.97	TRANSEX, D_SULWSI	Robust
	base: -0.083**	0.023	-3.68	0.21	2.14		
	low: -0.96**	0.023	-4.17	0.23	1.79	DENS-61, D_NOJAVA	
Transmigration 1990	high: 0.202**	0.035	5.83	0.42	2.09	TRANSEX, D_JAVA, D-SULWSI	Robust
	base: 0.119**	0.038	3.14	0.21	2.14		
	low: 0.115**	0.037	3.11	0.24	2.24	D_KALMTN	

Notes:

- (1) \*\* and \* indicate significant at  $\alpha=0.05$  and  $\alpha=0.1$ , respectively
- (2) The base  $\beta$  is the estimated coefficient from focus variables: cropping intensity (CI-POTEN), population pressure (PRESSURE), non-oil income per capita (GDP/CAP), and cumulative transmigration up to 1990 (TRANS-90). The high  $\beta$  is the estimated coefficient from the regression with the extreme high bound, and the low  $\beta$  is the estimated coefficient from the regression with the extreme lower bound.
- (3) Other variables are the Z-variables included in the base regression to produce the extreme bounds.
- (4) The variable is robust when the estimated coefficient falls within the range of  $\beta_j$  + two times its standard error and fragile when otherwise (see Levine and Renelt, 1992).

Table 5. Elasticities ( $\epsilon$ ) of Focus Variables for Regional and Provincial Data Sets, Computed at Means Values of Focus Variables

Focus Variables	Regional Data Set		Provincial Data Set	
	Mean	Std.Dev	Mean	Std.Dev
Land Degradation	64.87	29.87	73.87	63.61
Cropping Intensity	21.18	32.90	30.59	51.52
Population Pressure	4.21	0.73	4.20	0.82
Income per Capita	409.64	140.57	387.90	173.52
Transmigration	423.50	503.30	110.90	108.50

$$\text{Note: } \epsilon_j = \frac{\Delta y / y}{\Delta x_j / x_j} = \beta_j \cdot \frac{\bar{x}_j}{\bar{y}}$$

where  $\beta_j$  is regression coefficient of the  $j$ -th focus variable (see Tables 3 and 4), and  $x_j$  is its mean; and  $y$  is the mean of dependent variable.

**Table 6. Definition of Variables and Data Sources**

<i>Variable</i>	<i>Definition and Data Source</i>
E-UPL	The estimated rate of average annual soil loss in the upland, measured in ton/hectare. Estimates are based on a modified USLE using the data from RePPPProT (1990) and CBS (various issues).
CI-POTEN	Cropping intensity, ratio of harvested area of upland food crops to total potential arable upland, measured in percent, obtained from CBS (various issues).
PRESSURE	Population pressure, ratio of total population to labor force (or dependency ratio plus one), obtained from CBS (various issues).
GDP/CAP	Non-oil income per capita, in Rupiah, obtained from CBS (1990). Extrapolation was employed to fulfill the missing observation.
TRANS-90	Cumulative Transmigration up to 1990, collected from mostly from CBS (various years), and World Bank (1988). One-year data are repeated annually to create a 12-year series in the pooled data.
DENS-61	Population density in 1961, measured in people/km <sup>2</sup> , published by the CBS (1980). As in the case of transmigration, this one year variable is repeated 12 times for the pooled time series analysis.
POP-DENS	Population density at current year, also obtained from CBS. This static concept is one of the reasons not to choose the variable of population density as a proxy for population pressure.
POVER-87	A percentage of population under the poverty line in 1987, obtained from Booth (1989), p.307. This one-year variable is also repeated for the 12-year period of analysis.
TRANSEX	Expenditure on Transmigration, the expenditure of provincial development times percentage of development budget allocated to transmigration, measured in Rupiahs, also obtained from CBS.
D_NOJAVA	Dummy Variable for Non-Java, 1 for outside Java and 0 otherwise.
D_SUMTRA	Dummy Variable for Sumatra, 1 for Sumatra and 0 otherwise.
D_JAVA+	Dummy Variable for Java and Bali, 1 for Java-Bali and 0 otherwise.
D_MLK-NT	Dummy Variable for Maluku-Nusa, 1 for Mlk-Nusa and 0 otherwise
D_KALMTN	Dummy Variable for Kalimantan, 1 for Kalimantan and 0 otherwise
D_SULWSI	Dummy Variable for Sulawesi, 1 for Sulawesi and 0 otherwise

## Recent Working Papers

- WP 1993: 4 ANGELSEN, Arild  
*Individual choice under uncertainty*. Bergen, December 1993, 27 pp.
- WP 1994: 1 ANGELSEN, Arild  
*Shifting Cultivation and "Deforestation". A Study from Sumatra, Indonesia*. Bergen, November 1994, 28 pp.
- WP 1994: 2 SUMAILA, Ussif Rashid  
*Non-cooperation in fish exploitation. The case of irreversible capital investment in the Arcto-Norwegian Cod Fishery*. Bergen, December 1994, 24 pp.
- WP 1994: 3 ANGELSEN, Arild  
*Shifting cultivation expansion and intensity of production: The open economy case*. Bergen, December 1994, 52 pp.
- WP 1994: 4 RAKNER, Lise  
*Do interest groups matter in economic policy-making? Reflections from a Zambian case study*. Bergen, December 1994, 19 pp.
- WP 1994: 5 BØRHAUG, Kjetil  
*Local government and decentralisation in sub-Saharan Africa. An annotated bibliography*. Bergen, December 1994, 58 pp.
- WP 1995: 1 ANGELSEN, Arild and Ussif Rashid Sumaila  
*Hard methods for soft policies. Environmental and social cost-benefit analysis*. Bergen, March 1995, 23 pp.
- WP 1995: 2 NORDÅS, Hildegunn Kyvik  
*South African manufacturing industries - catching up or falling behind?* Bergen, March 1995, 40 pp.
- WP 1995: 3 ANGELSEN, Arild and Odd-Helge Fjeldstad  
*Land reforms and land degradation in Tanzania: Alternative economic approaches*. Bergen, July 1995, 38 pp.
- WP 1995: 4 FJELDSTAD, Odd-Helge  
*Taxation and tax reforms in Tanzania: A survey*. Bergen, November 1995, 35 pp.
- WP 1995: 5 FJELDSTAD, Odd-Helge  
*Valued-added taxation in Tanzania?* Bergen, November 1995, 27 pp.
- WP 1996: 1 STOKKE, HUGO  
*Institutional approaches to the study of international organisation*. Bergen, February 1996, 23 pp.
- WP 1996: 2 TJOMSLAND, Marit  
*A discussion of three theoretical approaches to modernity: Understanding modernity as a globalising phenomenon*. Bergen, July 1996, 24 pp.
- WP 1996: 3 KNUDSEN, Are and Kate Halvorsen  
*Income-generating programmes in Pakistan and Malawi: A comparative review*. Bergen, August 1996.
- WP 1996: 4 FJELDSTAD, Odd-Helge  
*Bistand og næringsutvikling. Noen kommentarer til St. meld. nr. 19 (1995-96)*. Bergen, August 1996, 17 s.
- WP 1996: 5 RAKNER, Lise and Tor SKÅLNES  
*Political institutions and economic reform: Zambia and South Africa in comparative context*. Bergen, September 1996, 44 pp.
- WP 1996: 6 RAKNER, Lise  
*Rational choice and the problem of institutions. A discussion of rational choice institutionalism and its application by Robert Bates*. Bergen, September 1996, 31 pp.